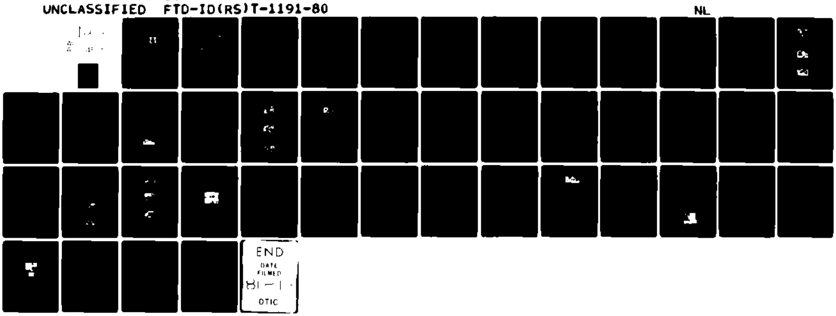
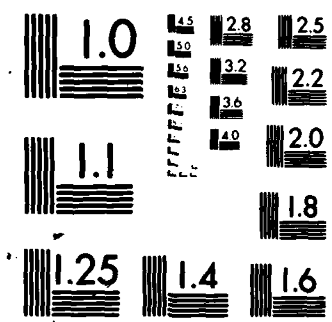
AD-A091 457   FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OH   F/G 20/5

A 20 YEAR'S SURVEY OF LASER SCIENCE AND TECHNOLOGY IN CHINA (L)--ETC(U)

OCT 80   J ZHONG, Q LI

UNCLASSIFIED   FTD-ID(RS)T-1191-80   NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

FTD-ID(RS)T-1191-80

AD A091457

FOREIGN TECHNOLOGY DIVISION

A 20 YEAR'S SURVEY OF LASER SCIENCE AND TECHNOLOGY IN CHINA (L)

by

Ji Zhong, Qun Li

80 10 29 038

FTD-ID(RS)T-1191-80

EDITED TRANSLATION

12 44

14 FTD-ID(RS)T-1191-80   11 2 Oct [redacted] 80

MICROFICHE NR: FTD-80-C-001051

6 A 20 YEAR'S SURVEY OF LASER SCIENCE AND TECHNOLOGY IN CHINA (L),

By: Ji Zhong Qun/Li

10 ~~English pages: 42~~

21 Edited trans. of

~~Source:~~ Laser Journal, Vol. 7, Nr. 1, January

(China) v7 n1 p1-12 Jan 80.

Country ~~of origin: China~~

Translated by: SCITRAN
F33657-78-D-0619

Requester: FTD/TQTA

Approved for public release; distribution unlimited.

A

THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT. STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN TECHNOLOGY DIVISION.	PREPARED BY: TRANSLATION DIVISION FOREIGN TECHNOLOGY DIVISION WP.AFB, OHIO.

14/600

It is already 20 years since the appearance of the first ruby laser.

The development of laser science and technology has witnessed an initial period of fundamental research and technical preparation and today has reached full development. From an international perspective, the major indication of full development is the development in depth of laser technology spanning the entire electromagnetic wave spectrum from far vacuum ultraviolet of about 1,000 angstrom to far infrared of 400 microns which have already attained laser emission. This represents a major breakthrough in certain laser parameters of the level of laser technology. For example, the neodymium glass laser system and the carbon dioxide laser have both reached to over 10^{13} watts, the pulse width of the ultra-short pulse laser has already been narrowed to 10^{-13} seconds and the He-Ne laser steady frequency has reached 10^{-16}. Laser technology has already become a strong research tool and a completely new technological path in the whole sphere of science and technology. It has already been widely applied causing new breakthroughs in old optics and solved many of the traditionally unsolved problems. Especially worthy of attention is that it has had a tremendous influence on and immeasurable significance in each of the branches of natural science. The monumental achievements accomplished in the 20 years of laser technology has already

caused people to be convinced and recognize that laser technology is a major invention of the twentieth century.

China's research for the development of laser technology was relatively early. In September of 1961, China successfully researched its first ruby laser. After this, new laser technology quickly developed in China. To strengthen its power, in 1964, a specialized laser institute was established in Shanghai. Later, departments under the Party's Central Committee and the State Council and local science committees also established laser technology research units. Up to the present, over 20 laser institutes have been established and at the same time, a factory for the production of laser parts and complete lasers was set up. Furthermore, production units for complete set components and materials initially formed an appropriate number of laser technology specialized contingencies.

Laser parts are a central problem for laser science and technological research. Up to the present, China has already successfully manufactured many types of lasers and basically has all of the parts that exist in foreign nations. Actually, there are about 40 types being used. The levels of China's neodymium glass laser system, continuous and repeat frequency YAG laser, He-Ne laser, sealed CO_2 molecule laser, selected room temperature CO molecule laser and $TEACO_2$ molecule laser have all come close to or reached that of the advanced ranks of the world. The components and materials used for the complete sets have gradually become serialized and commercialized. so that the research and

extended use of laser technology has provided advantageous conditions.

The use of laser technology in China possesses certain special characteristics. Application has already been extended to microprocessing, digging holes, welding, cutting, measuring, collimating directionals and precision range-finding all of which have had positive results. There are already over 40 types of fixed design laser instrument products. Laser medicine in China is original and over 130 types of illnesses have been treated. A great deal of clinical experience has been accumulated which is rarely seen in other countries. Especially significant is the development of the laser in ophthalmologic treatment. It is not only more developed but has also jumped to first place in the world for iris excision. The important uses of basic laser research such as laser control of thermonuclear fusion, laser communications and isotope seperation have made new progress. Lasers have already made a significant contribution in China for the building of socialism.

To accelerate the development of laser technology, the strengthening of academic exchange has been given serious attention. In the last 20 years, four national laser technology conferences have been held. Generally speaking, the first conference by means of theory and experimental proof resolved whether or not China was equipped with research on developing laser technology; the second conference showed the development of each type of laser and the great occasion of "a hundred flowers blooming in a riot

of colors"; in the third conference there was the joining of forces, exchange and the formation of a contingency; the fourth conference strengthened the foundation and raised stability. To adapt to China's repeated upsurge of the use of lasers during the 1970's, there were also convened many national and regional laser conferences. Table 1 lists in general information on a certain number of conferences.

Table 1 National Laser Technology Report Conferences and Exchange Conferences

Conference Name	Time	Place	No. of Participants	No. of Reports
First Conference of Light Quantum Amplification of Chinese Academy of Sciences	1/1962	Changchun	~40	~15
Second National Laser Conference	7/1963	Changchun	57	68
Third National Laser Conference	12/1964	Shanghai	140	103
Fourth National Laser Conference	7/1978	Canton	260	250
Gas Laser Technology Exchange Conference	11/1973	Canton	140	46
National Exchange Conference on Middle and Small Power Solid Laser Technology	9/1974	Changchun	220	70
Crystal Growth Research Exchange Conference	10/1974	Fuzhou	292	143
Symposium on the Use of Lasers in Agriculture	12/1974	Fushan	103	26

National Exchange Conference on Research of Semi-Conductor Lasers	6/1975	Peking	102	36
National Conference on Laser Power and Energy and Symposium on Laser Measurement Work and Experience	6/1975	Shanghai	93	15
National Conference on Laser Machine Processing	11/1976	Liuzhou	150	~ 100
National Exchange Conference on the Use of Lasers in Medicine and Laser Medical Treatment Technology	6/1977	Wuhan	300	~ 100

These conferences have been instrumental in stimulating scientific thought, strengthening technological exchange and the development of China's laser work. Especially in the last two years, scientific groups such as China's "laser branch of the applied optics group" and many provincial, municipal and autonomous region laser meetings have been set up. Lasers are one of China's eight major scientific research plans and it has already become an important discipline branch of China's modern optics. Its use is becoming more and more apparent.

"An Epitome"

The Shanghai Optics Institute of the Chinese Academy of

Sciences is an important base for the research and development of China's laser science and technology. The establishment and development of this institute has continually received the greatest concern and support from the party and nation. Just when China was developing new, advanced technology and showing its great vitality, under the personal care of the beloved Premier Zhou Enlai, the nation's science and planning committees decided to establish this institute. In 1973, Premier Zhou although very ill, attended the party's "tenth congress" and personally asked comrade Gan Fuxi about the laser work. He sincerely and earnestly issued the directive:"lasers should be developed and applied". In the last ten years, this institute has continually developed and grown and laser technology has made great headway. The workers and staff have grown from over 500 to more than 1400 persons and its laboratories have increased from 7 to 14. Here there is a powerful, solid scientific and technical contingency which includes many famous laser specialists and a group of first generation laser science and technology workers. The members of the contingency are relatively young, the average age being under forty. Their special features are that their work is clean and strong and their scientific thought is active. Among them some are developers of China's first laser research and many are the backbone of the concerted effort in laser science and technology. Furthermore, there are many promising young persons. During the 1978 National Science Conference, this institute was responsible for 16 projects and

also cooperated in 13 projects. They both conjunctively or as individuals were awarded great scientific achievement awards from the Chinese Academy of Sciences and the city of Shanghai. Seeing this abundance of capable people with so many achievements, one cannot help but think of the words of comrade Wang Daheng in his congratulatory telegram: "The two forces of Peking and Changchun are joined together in Shanghai all of who can be called 'very outstanding persons'".

The scientific research work of the Shanghai Optics Institute takes the development of a strong laser technology as its long-range direction, but at the same time researches each type of laser, laser material, component and other unit technology, investigates basic physics problems of the laser and actively develops and extends the application of laser technology. In these tasks, particular attention was paid to basics and improvements, far and near goals were combined, there was comprehensive development and an organic whole was formed.

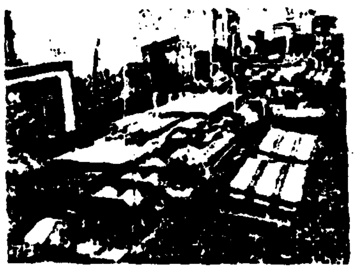
At the end of 1961, Deng Ximing of the Changchun Optics Institute alone formulated the modulated Q concept for a high power laser and had already proposed the use of the modulated Q plan for a machine rotating mirror. In 1963, another small group successfully developed the first ruby high power laser. This small group saw from experiments that the further advancement of this type of apparatus was limited by the measurement and mass of the ruby crystal. Because of this, beginning from the

end of 1964, it was resolutely decided to select a neodymium glass laser working substance as the main technological method. At that time, when outside of China there was still a controversy over this type of apparatus, this institute's research personnel independently chose this type of plan which was greatly signigicant for the fast development of China's high power laser technology. In the autumn of 1965, this institute successfully built domestically the first four pole traveling wave amplifying neodymium glass high power laser device. At the same time, in practice and theory, there was developed investigative research on laser nuclear fusion. In 1973, two 10,000 megawatt neodymium glass high power laser systems at the same time and for the first time there was a successful irradiation of the plane target of deuterate and lithium deuterium which initiated a fusion reaction that attained an output of nearly 1,000 neutrons/single pulse. During the following year, there was built a final stage using a large scale single channel laser system with a large aperture amplifier whose output power reached as high as 200,000 megawatts and whose pulse width was 2 millimicroseconds. This appatus' irradiated deuterium polyethylene plane target caused the neutron output to reach to over 20,000/single pulse. Naturally, the neutrons obtained from this type of simple targeting do not originate from the thermonuclear mechanism. To develop and thoroughly research the requirements for laser nuclear fusion, in 1975, this institute built a six channel high power laser device.

This was the largest experimental laser device built in China. In the spring of 1977, this device was put into use (total power output reached 200,000 megawatts, pulse width was 1 millimicro-second), many controlled experiments were carried out on the laser irradiated glass shell target and for the first time the initial compression effect of the laser drive's target substance was observed. This marked an important stage of advancement for China's research on thermonuclear fusion in trying to prove the principle of centripetal explosion. Since 1978, related basic research has obtained new advancements. The selected technological methods and experiments of this institute all possess their own special characteristics. For example, the neodymium glass, xenon lamp, laser membrane and other optical component systems used by the laser all employed domestically produced materials. Many of the key technical problems for the manufacture of laser plasma diognosis, high precision focusing on targets and plane and spherical fusion targets were all researched and solved by the institute. The high precision industrial television control and photoelectronic focusing technology used in the vacuum target chambers for the single channel and six channel devices were successfully researched by the institute's technical staff and workers at the end of 1973.

Picture 1 In July, 1979, Vice-Premier Fang Yi went to observe the Shanghai Optics Institute and personally inquired into the research and work on laser nuclear fusion.

Picture 2 Vacuum target chamber of the laser nuclear fusion six channel targeting device constructed in 1975.



Picture 3 Full view of $TEACO_2$ high power laser device

When developing the neodymium glass laser system, the transverse drive atmospheric pressure CO_2 high power laser device was also constructed. This system was composed of a lock type oscillator pre-amplifier stage, a large aperture ultraviolet pre-ionization amplifier stage and an electronic control amplifier stage of three connected parts. Not long after anticipated, it was used to carry out research and experiments on laser heating plasma.

In short, research on laser nuclear fusion, has gone through ten years of hard work, has already begun to take shape. Yet to make new breakthroughs, we must expend even more energy.

Aside from research on the high power laser system, this institute has also carried out research on various middle and small energy and power lasers. The following six categories sum up the essential ones:

1. The neodymium laser chiefly uses the silicate glass series which includes the single pulse device, repeating pulse device and ultrashort pulse device.

2. The crystal used in the crystal laser has ruby and yttrium aluminum garnet. The garnet device has a millimicrosecond pulse, high repetition rate pulse, ultrashort pulse and the continuous, frequency multiplier and tunable types.

3. The working gases of the gas laser are helium-neon, carbon dioxide, carbon monoxide, argon nitrogen, neon, methyl flouride, methyl alcohol steam and copper and aluminum steam.

Because the structure of the carbon dioxide device is different it is straight piped, folded, closed cycled and wave guided.

4. The semiconductor laser includes the gallium arsonide single heterogeneous device and double heterogeneous device. This has also developed research on light integrated lasers.

5. The quasi-molecular laser which has already attained the working system of laser output has xenon flouride, xenon chloride, xenon bromide and argon flouride.

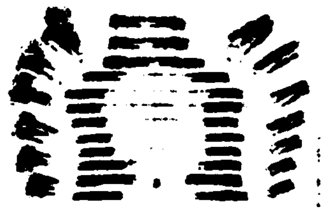
6. The dye essentially used in the dye laser in the garnet 6G and pump method which has a xenon lamp, an yttrium aluminum garnet laser, a nitrogen laser and an argon laser.

Table 2 lists in brief the representative lasers of the institute. From the list it can be seen that some of these lasers hold a leading domestic position, some fill in domestic gaps and some have already approached the advanced international level.

In the course of the development of lasers, the Shanghai Optics Institute has done a great deal of work for the needed components, materials, technology and unit technology. At present, they already have a strong foundation. For the manufacture of laser glass, the institute has already formed a relatively com- lete theoretical and technical system and finalized designs for more than ten laser glass varieties. Their quality and performance are better and furthermore, they are being mass produced and their use is widespread. Besides this, the institute has also developed an excellent ruby and yttrium aluminum garnet crystal. Recently,

they also used a unique technique and successfully made a Ø 52 millimeter x 45 millimeter large dimension sapphire. In respect to large components, this institute has skilled technology and abundant experience in making various types of high energy pulse xenon lamps, high repetition rate pulse xenon lamps and high power continuous krypton lamps. The performance of the high repetition rate pulse xenon lamps and the short pulse xenon lamps have already approached the advanced international level. Most of the other components which are suitable for various types of long waves such as the high reflection membrane, reduced reflection membrane, semitransmission membrane, crystal surface protective membrane and interference filter have attained to a relatively high level of quality. The unit technical work of this institute in fields such as optical design, photoelectronics, laser surveying, optical processing, testing and precision machines has all been outstanding.

Picture 4 Laser components, devices and materials



Picture 5 Various types of xenon lamps used by pump laser

The institute is actively preparing to export laser and optical products such as high repetition YAG lasers, TEACO_2 lasers, wave guide CO_2 lasers, laser glass, pulse xenon lamps, laser membranes, optical lenses, F-P standard tools and laser plane interferometers.

Based on the advancement of laser technology, basic research on lasers has been continuously strengthened and there have been positive results in each field of researh.

1. There has been a large amount of research carried out in laser theory, standard theory, standard measurement, identification and seperation, limitations under highly excited states, laser dynamics process, the best working conditions for the laser and the modulation and transmission of laser beams for the resonant cavity's new structure and cavity.

2. Technical research in laser non-linear optics such as frequency multiplication and high order harmonics, four wave mixing and frequency transformation, parametric oscillation and

amplification, self-focusing effect observation and surmounting have all reached relatively advanced stages.

Picture 6 Dr. Agnew of the United States Atomic Energy Company visited the mixing and frequency conversion laboratory of the Shanghai Optics Institute

Picture 7 Professor Lin Shaoji of the University of California visited the parametric oscillation and amplification laboratory of the Shanghai Optics Institute

Picture 8 Professor Salisi of Cambridge University visited the CARS spectrum laboratory of the Shanghai Optics Institute

Picture 9 Professor Tang Zhongliang of Cornell University visited the laser glass self-focusing laboratory of the Shanghai Optics Institute

Table 2 Middle and Small Power Lasers Developed by the Shanghai Optics Institute

(Translator's note: A= Sequence number B= Name of Device
C= Structural Characteristics
D= Performance Level E= Time Developed)

A. 1

B. YAG high repetition rate laser

C. To crystal rod is added filter liquor for cyclic cooling; two rods are connected; there is a multireflex turning mirror at focus Q; there is a water-cooling pulse xenon lamp pump.

D. Power output 100 megawatts; pulse width 6 millimicroseconds;

repetition rate 100 times/second; divergence angle 8 milliradian; 100 minutes continuous operation; 50 hours accumulated life. It has reached advanced foreign level.

E. Beginning of 1976- 8/1976.

A. 2

B. YAG continuous power laser

C. Two rods are connected; selected best pattern matching (designed product).

D. Power output 150-200 watts; divergence angle $<$ 10-15 milliradian; total power 1.3%; operating life (with one charge of krypton lamp) 50 hours.

E. Beginning of 1978- beginning of 1979.

A. 3

B. YAG dye locked laser

C. Semi-focal cavity; single transverse action using five lock patterns.

D. Output pulse width 20-200 millimicroseconds; single pulse energy 1 millijoule; output single pulse rate $>$ 90%. Space, time and frequency all high distribution and energy stability better than 80% which reaches the advanced domestic level.

E. 1976- beginning of 1979.

A. 4

B. YAG high power frequency multiplication laser

C. One pole oscillation; one pole amplification; KDP frequency multiplication

D. Green light output reaches as high as 0.532 millimeters of 0.1 joule; pulse width 4 millimicroseconds; divergence angle 0.5 milliradian; repetition rate 0.5/second. Reaches advanced domestic level.

E. 1978- 9/1979

A. 5

B. Solid high power frequency multiplication laser

C. YAG oscillator with three pole ND glass amplifier; KDP and KD*P frequency multiplication.

D. Energy transformation efficiency over 60%; power transformation efficiency 79%; highest frequency multiplication output to 1 joule; pulse width 6 millimicroseconds; divergence angle smaller than 0.3 milliradian. It reaches advanced foreign level.

E. 1977- 2/1979

A. 6

B. ND glass picosecond laser

C. Composed of dye lock oscillator, single pulse selector and tetrapolar amplifier.

D. Outpulse pulse width 10 millimicroseconds; peak value power 10^{10} watts; divergence angle 0.5 milliradian which are at advanced domestic level. Output pulse width of other locked oscillator is 5 millimicroseconds; peak value power 10^{8} watts; divergence angle 1 milliradian which approaches advanced foreign level.

E. 1977- 6/1979

A. 7

B. Cold electron beam control CO_2 laser

C. Cold cathode electron gun; excitation volume 8 liters (length 1.7 meters); working gas 1.6 atmospheric pressure.

D. Greatest laser energy 430 joule; greatest light energy density 54 joule/liter; pulse width 1-3 microseconds; efficiency 10-16%; light energy density approaches present foreign level.

E. 1974- 10/1975

A. 8

B. Thermoelectron beam control CO_2 laser

C. Thermocathode electron gun; excitation volume 3.7 liters; working gas 1 atmospheric pressure.

D. Greatest laser energy 240 joule; greatest light energy density 68 joule/liter·atmospheric pressure; peak power 50-100 megawatts; average power 30 megawatts; efficiency 10%. Light energy density approaches present foreign level.

E. Beginning of 1974- 10/1975

A. 9

B. JG-1 type three fold CO_2 laser

C. Composed of a three water cooled discharge tube plane bend, the laser cavity uses an expanded volume multilens cavity, the length of the cavity is 6.5 meters, the power distribution source makes up a whole machine and there is an air-filled platform.

D. Continuous output is 500 watts; continuous operation is 300 hours; it has a life of 10,000 hours; it can be used to air-

filled again; its power has reached the level of foreign devices of this type and yet using a sealed and seperate form operation is economical.

E. 3/1975- 12/1975

A. 10

B. JG-2 type six fold CO_2 laser

C. The entire machine is composed of six water cooled discharge tubes which make space for the cylinder type fold; cavity length 12.5 meters and a power source. An air-filled platform is appended.

D. Continuous output is 500 watts; it can operate continuously; it has a gas storage flask; it can be used for sealing and seperating and its operation is economical.

E. 3/1975- 12/1976

A. 11

B. Crossflow closed cycle CO_2 laser

C. Composed of a discharge case, an air-blower, a heat exchanger and a cyclical passage; a one way level concave cavity. The length of the cavity is 1.25 meters; the excitation length is 86 centimeters.

D. Highest output is 2.9 kilowatts; the level is the same as that of a similar American device and is China's first successful operation. Its power is the highest kilowatt stage of the crossflow closed cycle CO_2 laser.

E. 8/1977- 10/1979

A. 12

B. Wave guide CO_2 laser

C. Uses pylex glass to make a dielectric wave guide discharge tube; its diameter is 1.5 millimeters; its length is 130 millimeters and its inner cavity is flat.

D. Output power is 2 watts; it has a transverse type EH_{11}, its unit activation length has an output power of 0.15 watts/ centimeter; its unit activation volume has an output power of 9.2 watts/centimeter^3; it operates continuously and approaches the level reported by foreign nations.

E. 4/1978- 3/1979

A. 13

B. CO_2 selection laser

C. Uses a piezoelectric ceramic self control return circuit control cavity, a grating coupling to select dissimilar wave-lengths, an invar support and the cavity is sealed.

D. Within a 9.4-10.4μ range, it can select 80 spectrum lines; power output is 10-20 watts and it has a single TEM_{00} model. When operating under 10 watts, its frequency rate stability is -10^{-8}, its power stability is 2% and its accumulated life is 5000 hours.

E. 4/1975- 11/1979

A. 14

B. CO selection laser

C. At room temperature the CO electric drive laser uses grating

selection, the discharge tube has a length of 1.3 meters and the internal diameter is ϕ 12 millimeters.

D. At the beginning of 1979, within a 5.3-5.7μ range, it can select 60 spectrum lines. Its greatest single support power is about 6 watts which reaches the level reported by foreign nations. In oct., 1979, after the appropriate handling of the electrodes, power was raised to 9 watts and its life reached to over 550 hours.

E. 10/1978- 10/1979

A. 15.

B. Fast discharge pump quasi-molecule laser

C. Uses a flat and parallel transmission line Brumlein circuit; works under 1 atmospheric pressure and has an external cavity structure.

D. In the XeF system, it attains a 162 spectrum which is 124 more than that produced by foreign nations.

E. 3/1978- 10/1979

A. 16.

B. Ultraviolet preionization high atmospheric pressure quasi-molecule laser

C. Uses an ultraviolet light preionization discharge pump, works with a 2-3 atmospheric pressure, has a cylindrical discharge tube and an internal cavity structure.

D. In the KrF, ArF, XeCl, KrCl and XeBr systems, laser oscillation occurs. The bromide used in the XeBr system is an original

creation and the ArF system has attained 193 millimicron wave length which is the shortest domestic oscillated wave length.

<u>ـ. 6/1979- 7/1979</u>

A. 17

B. YAG laser pump dye laser

C. Composed of YAG oscillation amplifier; frequency multiplication and frequency, and dye laser; over 10 types of dye were used.

D. Could be tuned within 0.28-0.7 μ ; continuous operation for 8 hours; repetition rate of 1-10 times/second. When G is in the range of 0.53-0.56 μ , transformation efficiency reaches 30%. It is at an advanced domestic level.

<u>E. 1975- beginning of 1978</u>

A. 18.

B. Xenon lamp pump dye laser

C. Repetition rate pulse xenon lamp pump (?)6G dye; dye cycle flow.

D. Tuning wave length is 4400-7000 Å (band width of 0.5A); repetition frequency rate is 40 times/second. Peak power is 2×10^4 watts (average 1 watt); pulse width is 0.6 milliseconds; divergence angle is 1-2 milliradian.

<u>E. 11/1978- 11/1979</u>

A. 19

B. Pentaphsophoric acid neodymium small type crystal laser

C. Uses the crystal xenon lamp pump and dye laser transverse pump developed by Shandong University.

D. In 1 millimeter thick crystal the output power is 30 watts; single pulse peak value power is over 300 watts; slope light quantum efficiency is 15%; laser threshold value is 24 millijoule. It filled in a domestic gap at the same time as the Xian 205 xenon lamp pump device.

E. 1978- 1/1979

A. 20

B. Tetraphosphoric acid neodymium lithium small type crystal laser

C. This institute made the tetraphosphoric acid neodymium lithium crystal itself and used the xenon lamp pump and dye laser transverse pump.

D. In 0.5 millimeter thick crystal the output power is 20 watts; single pulse peak value power is 200-300 watts; slope light quantum efficiency is 18% and laser threshold value is 16 millijoule. For the first time domestically there was output at room temperature.

E. Beginning of 1979- 6/1979

A. 21

B. Copper atom vapour laser

C. Uses the working materials of copper halogenide and pure copper vapour and uses resonant Blumlein circuit self heating and self drive, and is filled with Ne20.

D. Wavelength 5106Å and 5782Å have pulse widths of 30 millimicro-seconds. In Nov., 1978, it emitted light thus filling in a

domestic gap. The present average output power is 1.8 watts and the pulse repetition frequency rate is 16 kilohertz.

E. 5/1975- 8/1979

A. 22

B. Light pump distant infrared laser

C. Uses CO_2 laser for pump source so that the organic molecule vapour is a working substance; an invar support and room temperature water cooling.

D. In Dec., 1978, the pump of methyl fluoride vapour attained a laser output of 496 μ wavelength representing the highest domestic oscillation wave length at the time. In May and June of 1979, the pump of methyl alcohol vapour attained a laser output of 70 μ and 118 μ wavelength which acted to fill in a domestic gap.

E. 1978- 6/1979

2. In the field of strong ray radiation effects, they researched strong lasers of different parameters in relation to the destructive mechanism and law of various translucent, non-translucent and metallic mediums.

3. In the area of laser plasma physics, they reached high power laser and plasma interaction of certain mechanisms and investigated the physical models of laser centripetal explosion.

The historical course of the development of laser technology by this specialized research institute reflects an epitome in the development of China's laser work, yet it is still in-

complete. Because of this, the technical personnel of this institute are still actively participating in domestic academic exchange, exchanging their own experiences, and studying the strong points of others to advance their own work. Especially in the last several years, international contacts have been even more frequent and according to statistics, since 1972, China has received over 90 foreign guests from 20 nations. Among over 200 people, there were among them many internationally noted laser specialists who carried out scientific exchange with this institute's scientific and technical staff. Some also carried out short term work in this institute. In this way, the academic atmosphere of this institute has become very active.

Picture 10 In Sept., 1978, a representative group from the Yugoslavian Science and Technical Institute visited the Shanghai Optics Institute

Picture 11 In June, 1979, a representative group from the Japan Science and Technology Conference visited the Shanghai Optics Institute

Picture 12 In Sept., 1979, the American Electricity and Electronic Engineering Institute (IEEE) group visited the Shanghai Optics Institute

Picture 13 In Sept., 1979, the chairman of the International Optics Committee, Professor Loman , of West Germany's Erlangen-Nuremberg University visited the Shanghai Optics Institute

Picture 14 In June, 1979, Professor Wang Zhengping of the University of California visited the Shanghai Optics Institute

The Entire Process

Today, after 20 years of quick development in laser technology, looking back, the entire process of the development of the first laser- the ruby laser, is a very interesting remembrance. The picture below shows the experimental device for China's first ruby laser.

Picture 15 Experimental device for China's first ruby laser

In Changchun, the Chinese optics specialist Wang Daxing led a group of optics research workers during the latter part of the 1950's to probe into some of the difficulties encountered in his own work. The final result of whether they could surpass several "impossible" restricted areas, as in light source brilliance in the area of classic optics, was they could only weaken it but could not raise it; the laser beam tended towards dispersion and not the opposite; the image tended toward blurriness and not the opposite; the wave length could only become longer and could not

become shorter. Then comrade Gu Quwu suggested a new idea. Place a luminous body in a Fabry-Perot interferometer for the purpose of extending the light wave wave train at a certain frequency to raise the monochromaticity. When this thought was actively collectivized with readings on the ideas of Xiao Luo and Tang Si regarding light excitation, then they began concrete investigation. Therefore, Mei Man's success acted to speed up the pace of Changchun's optics workers. At the time, Wang Zhijiang, a young optics specialist, based on China's actual circumstances, carried out a series of theoretical analyses and calculated a suitable testing plan for China. He also led and completed China's first laser experiment. Because the length of the already existing ruby crystal was only 30 millimeters, it was considered that by using a spiral xenon lamp for light pump transformation, efficiency could not be high. The use of a straight tube xenon lamp and a spherical imagery coupling spotlight system was more rational. The first Chinese style ruby laser was born out of this design idea. For the entire parameter see table 3.

Table 3 Essential Technological Parameter of the First Ruby Laser

Device	Essential Parameter
Ruby rod	Chromium ion concentration: 0.04% Length 30 millimeters, Ø 5 millimeters One part completely of silver-plating, and in the other part the silver-plating has a penetration rate of 2-15%.

Straight tube pulse xenon lamp	Electrode space: 40 millimeters Inner diameter: 8 millimeters
Spotlight cavity	Two reflecting hemispheres, the radius of the sphere is 90 millimeters
Power source	Electric capacity: 2660 microfarad Voltage: 350-550 volts

In July, 1961, this laser was put into operation for the first time and a flourescent phenomenon was seen. After two months of hard work, in July, 1961, when examining the device's output, in a several meter distance there was an apparent difference in the flourescence brightness facula. In light of the use of photoelectric measurement and the "peak" effect shown by the oscilloscope, laser output was confirmed. Using a photoelectric farad count to obtain the pulse output the energy was about 0.003 joule. Leaving that aside for the moment, China's announcement of success was two months earlier than the same category of experimental results of the Soviet Union. The entire process of the conception and birth of this laser, whether it was for design ideas or for the various difficulties of each technical segment, all reflected that there was achievement in research and the spirit of self reliance.

If it is said that the birth of the first laser is only seen as a beginning then how should its use be appraised? Here, there is no harm in giving the reader a section of a published report:

"Another example of an important development area is excited emission, especially excited laser emission. From excited laser emission we can attain a beam of exceptionally narrow, monochromatic, coherent light waves, and its strength far exceeds former capabilities. This brings forward a completely new and acute tool for basic scientific research, opens up new horizons in atom and molecular physics and establishes totally new optics and other strong light effects research. In optics, it forms a branch of strong light optics. Excited laser emission not only influences the basic discipline but it can also open vast vistas in engineering technology, in the status, surveying and tracking techniques of long-range aircraft and also has the potential for creating new cosmic communications. Because of this, the extension and development of excited emission technology can possibly in the next ten years bring on a great wave in science and technology and establish a very advanced technology."

This quote comes from the Chinese national science development plan outline (draft) and is an appraisal of this new area of lasers. When reading this appraisal today, it still has not lost its guiding function.

Competitive Development

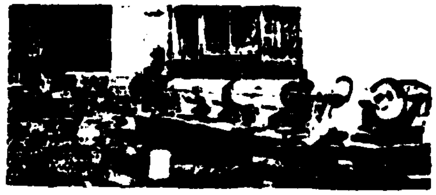
The emergence of China's first ruby laser opened a door for the development of China's laser technology and afterwards each type of laser, like the rain bringing on bamboo shoots in spring, developed competitively. Here we will only mention the development of several major types of lasers which were the distinguishing feature of the development of laser technology during the 1960's. According to statistics, China presently has over 40 types of lasers. Table 4 lists the major lasers and the times they were first put into operation.

Table 4 Various types of lasers and the times they were first put into operation

Name of device	Time
Ruby laser	9/1961
He-Ne laser	5/1963
Neodymium glass laser	6/1963
CaF_2: U^{3+}laser	6/1963
GaAs P-N joined laser	12/1963
$CaWO_3$: Nd laser	1964
Pure Xe, HeXe laser	1964
CaF_2: Dy^{2+} continuous infrared laser	1964
CO_2 molecule laser	1965
Argon ion laser	1965
Krypton ion laser	1965
HCl chemistry laser	1965
Inorganic liquid laser	1967
YAG laser	1968
GaAs-GaAlAs double differing joined laser	1971
CO_2TEA laser	1971
CO_2 pneumatic laser	1972
DF,HF pneumatic chemistry laser	1973
N_2 laser	1973
Iodine atom laser	1974
Gas exploding pneumatic laser	1974

Room temperature continuously operating double differing laser	1975
Solid explosion pneumatic laser	1975
Continuous tunable dye laser	1975
Xenon fluoride quasi-molecular laser	1977
XeBr, XeCl quasi-molecular laser	1978
Electron beam pump XeF quasi-molecular laser	1978
Pentaphosphoric acid neodymium laser	1978
Room temperature CO molecular laser	1978
Room temperature selection CO molecular laser	1978
HCN far infrared laser	1978
16μ CO_2 laser	1979
Tetraphosphoric acid neodymium lithium laser	1979

The picture below is a high energy neodymium glass laser. China's first neodymium glass laser which attained laser oscillation was made in May, 1963 in the Changchun Optics Institute. The glass substances were made by the institute. At the time, comrade Gan Fuxi, on the basis of his many years of research on optical glass, sought a silicate base material and a suitable dye concentration and successfully developed a laser glass substance which is the basis of today's neodymium glass system. Up to the present, China's high power neodymium glass laser system has reached 2-3 x 10^{11} watts[f.n.1] and is in the process of erecting a 10^{12} watt device.



Picture 16 High power neodymium glass laser

The He-Ne laser is presently the most popularly used gas laser device. According to statistics, China has about 80 factories that have researched and produced the He-Ne laser device units. Among them, many factories have already set up assembly lines to carry out production and national yearly production of He-Ne laser tubes is about 15,000. The measurements of the commomly used devices are 240 millimeters and 300 millimeters. The life of the laser tube is several thousand hours, some units use low melting point glass sealed new technology[f.n.2], and the life of the device has already reached 10,000 hours. Improvements were made on the laser tube causing the electric discharge firing voltage to be one-third lower than the usual tube.[f.n.3]

---

f.n. 1 Shanghai Optic Institute's Laser Nuclear Fusion Laboratory of the Chinese Academy of Sciences: "Experimental research on the six beam laser irradiation of a microspheric target", Laser, 5/1978, nos. 5-6, p.9.

f.n. 2 "Using the method of a low melting point glass sealed helium-neon laser tube", Laser, 6/1979, no. 8, p. 50. "Low melting point glass sealed technique for optical windows and laser cavity", Laser, 6/1979, no.9, p. 39.

f.n. 3 "Methane saturation and absorption stabilized helium-neon laser", Laser, 5/1978, nos. 5-6, p. 141.

When a methane saturation and absorption stabilized He-Ne laser is used in a sampled time of 1 second and 10 seconds, the degree of stabilization is better than 1×10^{-11} and reappearance is over 4×10^{-11}. In many experiments, stabilization and reappearance also reached to over 10^{-14}. When an iodine absorption stabilized frequency device is used in a sampled time of 1 second, the degree of stabilization is $(2-3) \times 10^{-11}$, and when the sampling time is 10 seconds, stabilization is 5×10^{-11} and reappearance is 2×10^{-10}.[f.n. 4]

Only if we raise the quality of the He-Ne laser, especially the life of the laser, can it play a role in application. From 1975 to 1979, China organized seven technical exchange meetings where they contrasted performance and measurement, discussed key technical problems and technical exchange on the He-Ne laser.

The first He-Ne laser was manufactured in May, 1963 which has gone down in the history of China's laser development. At the time, the device's output power was about 1 milliwatt and it's light beam divergence angle was smaller than 0.00032 radian. Two years later, the He-Ne laser had final design production and was being sold commercially which we can see was a fast development.

The CO_2 gas laser is also a commonly used gas laser. The number oftypes of CO_2 gas lasers are very numerous in China and

f.n. 4 "Study of the performance of the iodine saturation and absorption stabilized helium-neon laser", Laser, 5/1978, nos. 5-6, p. 142.

the common sealed ion CO_2 laser which has output power of under 500 watts can, at present, produce a one meter single mode output of 52 watts and it's continuous firing is more than 5,000 hours.[f.n.5]

In 1965, when the CO_2 laser was just beginning to be researched, research conditions were very difficult. The CO_2 gas used was all obtained from $CaCO_3$ which was heat decomposed by the experimenting staff and after a series of experiments they then obtained spectrum pure CO_2 gas. Naturally, later experiments proved that gas purity was not an important factor. Yet, as the process of the scientific research was tortuous it did act as a reference for later experimenters.

Research on the pneumatic CO_2 laser began in 1971, the discharge was a 10 kilogram combustion type device and continuous output power was 37,000 watts.[f.n.6]

Using the two working series $H_2 + CO + N_2$ and $C_2H_2 + CO + O_2 + N_2$ gas explosion pneumatic laser, output energy reached 500 joule and laser pulse width was 500 milliseconds.[f.n.6] The picture below is a pulse gas explosion laser.

Picture 17 Pulse gas explosion laser

Using the four solid explosive substances of nitrogen bearing highest tetranitrourea, RDX, 662 and 7201 and successfully researching the solid explosion pneumatic laser, we attained an energy output of 8.6 joule and a pulse semi-width of 10-40 microseconds.[f.n.6]

From 1972 on, development began on the cross flow device. The presently developed cross flow closed cycle device has a continuous output power of up to 2 kilowatts[f.n.7] and on the average each centimeter has a discharge length ratio output of 20 watts.

In 1971, China also successfully developed the cross excitation high atmospheric pressure laser and the $TEACO_2$ laser. At present, the level of this device is: highest output energy 400 joule/ liter·atmospheric pressure[f.n.8]; pulse width of locked mode $TEACO_2$ laser is several millimicroseconds.

---

f.n. 5 "Influence of electrode and gas composition on the life parameter of a carbon dioxide laser." in [Meeting Establishing the Chinese Optics Society - Collection of Abstracts of Academic Reports], Nov.18, 1979.

f.n. 6 "The carbon dioxide pneumatic laser", Laser, 5/1978, nos. 5-6, p. 49.

f.n. 7 "The cross flow CO_2 laser with a continuous output of 2 kilowatts", Laser, 6/1979, no. 8, p. 63.

f.n. 8 "The electron beam control electrical discharge laser", Laser, 5/1978, nos. 5-6, p. 55.

Aside from the above two mentioned types of gas lasers, China also successfully developed the krypton ion, argon ion, metallic vapour and quasi-molecular gas lasers. These lasers also attained gratifying development.

The semiconducting laser was also one of China's early period lasers. It was first successfully developed in Dec., 1963 by the Semiconducting Institute of the Chinese Academy of Sciences. The working substance was gallium arsenide P-N junction, it used the diffusion method to develop an experimental sample, it's cuboid measurement was 0.15 x 0.2 x 0.8 millimeters^3, the two reflecting surfaces of the resonant cavity used it's cleavage surface, the pulse of the laser power source had a rectangular width of 2 microseconds and it operated when placed in a temperature lower than 77° K. When the electric current was very small, luminosity was the same and the spectrum line width was wider - 170 angstrom. When the electric current was increased, the luminosity peak value wave length position shifted to the short waves and the spectrum line width decreased. After the electric current exceeded 2,600 amperes/centimeter, the spectrum line became narrow, smaller than 10 angstrom. With the use of a high polymer grating spectograph we can see the fine structure of the emission spectrum. The short coherent radiation wave is close to 8,400 angstrom and the width of the ray is smaller than 0.5 angstrom.

The semiconducting laser which China has already developed also has a heterojunction GaAs laser, a double heterojunction

GaAs laser, a YAG light pump diode and a tunable tin telluride lead semiconducting laser. The pictures below are a double heterojunction semiconductor laser and an experimental apparatus. This device has a continuous operational life of 5,000 hours at room temperature.[f.n.9]

(to be continued)

Picture 18 Semiconductor laser and it's experimental apparatus

f.n. 9 "The 500 hour room temperature continuous excitation emission GaAs/GaAlAs double heterojunction laser", Laser, 6/1979, no. 7, p. 44.

The National Science Committee Holds A Conference On Commonly Used Lasers

by Tao Yongxiang

From Nov. 30 to Dec. 6, 1979, the National Science Committee held a conference in Tianjin on commonly used lasers. The conference was for the overall organization and planning of China's present development, for the various areas in desperate need of the commonly used lasers and for relevant components, scientific research of materials, experimentation and production work. The conference had the strong support of the national planning committee and national economic committee. Ninety representatives from the National Planning Committee, Chinese Academy of Sciences, First Ministry of Machine Building, Fourth Ministry of Machine Building,, Ministry of Education, provincial and metropolitan science committees and other related research institutes, factories and institutions of higher learning attended the conference.

Before the conference, the National Science Committee had organized manpower to carry out practical research on the focal points of China's commonly used lasers. They discovered that the present existing problems for China's commonly used lasers were: varieties were few and quality was lacking; there was a lack of Chinese experiments and research results were not quickly disseminated for productive forces; the nation lacked unified plans and leadership; the work on some devices had a great deal of repetition and for some devices nearly no one made inquiries

about them; suitable assemblage components, materials and surveying equipment lacked assemblage arrangements. With the proclamation of these problems, related departments of the Science Committee, based on the overall planning for the nation, selected the best principles and made proposals for national focus of research, production, planning and conference discussion on the commonly used lasers over the next two years.

They energetically discussed problems that had opened up and the developments domestically and abroad in the field of commonly used lasers. With this foundation, they decided the focus of research and production plans for the He-Ne laser, CO_2 laser, argon ion laser, Nd:YAG laser, ruby laser, neodymium glass laser and the tunable dye laser; the ruby laser crystal, Nd:YAG crystal, laser dye, non-linear crystal, pump lamp, laser reflecting mirror, laser partial light mirror, electric light modulator, sound light modulator, standard tools and laser stored energy electric capacity.

The conference decided: for the partial responsibility of the planning stipulations during the next two years, use the contract system for the economic handling of scientific research and production; at the end of 1980 hold a national assessment conference on commonly used lasers to examine the practicable conditions of the spirit of the conference and review the achievements in work on the commonly used lasers.

A 20 years' survey of laser science and technology in China

The correspondent *Ji Zhong* The reportor *Qun Li*

Summary

The historical process and some achievements in the field of laser science and technology in China are presented briefly. First of all, an epitome is given to the readers, and then the entire process of the development of the first ruby laser in our country is revealed. It is shown that various types of lasers were developed in competition during 1960's, and laser application researches emerged one after another in 1970's, moreover, an urgent appeal for enhancing the fundamental research was made. A typical laboratory is introduced. The opto-electronic industry in pregnancy attracts wide attention.